



Smart Hospital Token Booking and Queue Management System

¹Dr Geetha MCS, ²Pratheeksha H

¹Associate Professor, ²Student,

¹Department of Data Science,

¹Kumaraguru College of Liberal Arts and Science, Coimbatore, India

Abstract: The rapid increase in patient inflow in hospitals has created major challenges in managing appointments, queues, and service efficiency. Traditional ways of handling tokens in hospitals and just scheduling things by hand usually lead to people waiting forever. There is overcrowding too, and it is hard to know what is going on, plus resources do not get used well at all. I think that is a big issue in healthcare. This paper talks about a Smart Hospital Token Booking Web Application. It is meant to handle patient flow digitally. Things like generating tokens in real time, scheduling doctors by department, predicting how long consultations might take, and even rescheduling tokens automatically. That seems like it could make things smoother. The app has authentication for users and admins. It lists hospitals based on the city, shows doctor duties that change dynamically, and includes dashboards to check on rush times and how services are performed. Some parts might overlap a bit, but overall, it monitors patterns. It was built with Python Flask for the backend, HTML and CSS for the front, and SQLite as the database. This setup should handle data securely, scale up if needed, and be easy for people to use. I am not totally sure about every detail, but it feels practical. Furthermore, the integration of data analytics and machine learning models enhances predictive scheduling and operational decision-making. The results demonstrate that the system significantly reduces patient waiting time, improves hospital workflow efficiency, and enhances transparency for both patients and administrators, highlighting the potential of digital healthcare platforms in modern hospital management systems.

Keywords - Smart Hospital System, Digital Token Booking, Queue Management, Appointment Scheduling, Healthcare Web Application, Predictive Analytics, Machine Learning in Healthcare, Patient Flow Optimization, Hospital Automation, Real-Time Scheduling

I. INTRODUCTION

1.1 Background of the Study:

Healthcare facilities across the world are facing increasing operational demands due to population growth, urban expansion, and rising healthcare needs. Overcrowded hospitals and inefficient patient handling have become common issues, particularly in high-volume medical centers. Traditional appointment booking and management methods rely heavily on manual processes, which are prone to errors and lack real-time adaptability. Such systems struggle to accommodate sudden surges in patient inflow, delays in doctor availability, and dynamic scheduling requirements. With the advancement of digital technologies, web-based healthcare management solutions have emerged as effective tools to streamline operations. Automated token systems offer transparent queue handling, real-time updates, and predictive scheduling, significantly enhancing both patient experience and hospital efficiency.

1.2 Problem Statement:

Despite technological progress, many hospitals continue to use outdated or partially automated systems for managing patient queues. These systems often lead to prolonged waiting times, poor coordination between departments, inefficient scheduling of doctors, and limited access to real-time information for patients. Additionally, the lack of analytical capabilities prevents hospital administrators from effectively predicting rush hours and optimizing resource allocation. There is a growing need for a fully integrated digital system that combines real-time queue management with predictive analytics.

1.3 Motivation and Significance:

The rapid growth in patient visits to healthcare institutions has intensified the challenges associated with appointment scheduling and queue management. Many hospitals continue to rely on manual or semi-automated token systems, which often result in long waiting times, overcrowding, inefficient use of medical resources, and poor patient experience. These issues become more critical during peak hours, where the lack of real-time coordination and predictive planning leads to operational inefficiencies. Although digital healthcare solutions have gained attention, most existing systems focus primarily on basic appointment booking and lack intelligent features such as real-time queue updates, automated rescheduling, and predictive estimation of consultation durations. There is a growing need for a comprehensive system that can adapt dynamically to changing patient inflow and doctor availability while providing transparency to both patients and hospital administrators. The motivation behind this research is to address these limitations by developing a smart, web-based hospital token booking and queue management system that integrates automation and predictive analytics. By leveraging machine learning techniques, the proposed system aims to anticipate rush conditions, optimize scheduling decisions, and reduce patient waiting time. The significance of this work lies in its practical contribution to modern healthcare management. The proposed system enhances operational efficiency by automating token allocation and consultation scheduling, thereby minimizing delays and improving workflow coordination. Additionally, the inclusion of analytical dashboards enables administrators to gain valuable insights into patient flow patterns, departmental workload, and service performance. This data-driven approach supports informed decision-making and continuous improvement in healthcare services. Overall, this research highlights the importance of integrating predictive analytics and digital automation in hospital management systems. The proposed solution not only improves patient satisfaction but also contributes to the advancement of smart healthcare infrastructure, making it highly relevant for contemporary healthcare environments.

1.4 Objectives of the Research:

The primary objective of this research is to design and develop a web-based hospital token booking system that simplifies and digitizes the patient appointment process. By automating queue management and appointment scheduling, the system aims to replace manual and time-consuming practices with a more structured and efficient approach. The study also focuses on integrating predictive analytics to estimate consultation durations, enabling better time management for both patients and healthcare providers. Through these features, the system seeks to significantly reduce patient waiting times while improving overall hospital workflow efficiency. Additionally, the research emphasizes the use of analytical dashboards to support hospital administrators in monitoring operations, identifying bottlenecks, and making informed data-driven decisions to enhance service delivery.

1.5 Organization of the Paper:

The remainder of this paper is organized as follows. Section 2 presents a review of related research works focusing on hospital queue management, digital appointment scheduling, and the application of predictive analytics in healthcare systems. Section 3 describes the overall methodology of the proposed Smart Hospital Token Booking and Queue Management System, including data collection, system architecture, and machine learning models used for prediction and optimization. Section 4 discusses the experimental results and performance analysis, highlighting the effectiveness of the system in reducing patient waiting time and improving workflow efficiency. Section 5 outlines the practical applications and implications of the proposed system in real-world healthcare environments. Finally, Section 6 concludes the paper and provides directions for future enhancements and research.

Literature Review

2.1 Review of Existing Work:

Several research studies have been conducted to address the challenges associated with appointment scheduling and queue management in healthcare environments. Traditional hospital management systems mainly focus on patient record maintenance and billing operations, offering limited support for real-time queue monitoring and dynamic scheduling. As patient inflow increases, these systems often fail to handle peak-hour congestion effectively. Recent studies have explored digital appointment booking platforms to reduce manual intervention and improve accessibility. Machine learning-based scheduling models have been proposed to predict patient waiting times and optimize appointment slots. These approaches have demonstrated improvements in scheduling accuracy and patient throughput; however, many of them rely on historical data without providing real-time adjustments during unexpected delays or sudden increases in patient volume. Research on automated queue management systems highlights the importance of real-time data analytics in monitoring patient flow. Some systems utilize sensor data, time-based analysis, or rule-based models to manage queues dynamically. While these solutions reduce waiting times to an extent, they often operate as standalone components and lack integration with hospital-wide scheduling and administrative decision-support tools. Web-based hospital management platforms have also been introduced to enhance scalability and ease of access. These systems provide features such as online appointment booking, doctor availability display, and basic notifications. Although they improve transparency, most existing platforms do not incorporate predictive analytics or automated rescheduling mechanisms, limiting their effectiveness during peak demand periods. Recent advancements in predictive analytics and machine learning have shown promising results in forecasting hospital rush hours and consultation delays. Time-series models and classification techniques are commonly used to identify high-demand periods and support resource planning. Despite these developments, there is still a lack of comprehensive systems that combine real-time token management, predictive scheduling, and analytical visualization within a single integrated framework. Based on the review of existing work, it is evident that current solutions address individual aspects of hospital queue management but do not offer a unified, intelligent platform. This research aims to overcome these limitations by proposing an integrated Smart Hospital Token Booking and Queue Management System that combines automation, predictive analytics, and real-time monitoring to improve overall healthcare service efficiency.

2.2 Research Gaps Identified:

Existing hospital appointment and queue management systems primarily focus on basic scheduling functions and lack real-time adaptability. Most solutions do not effectively integrate predictive analytics to estimate consultation durations or manage peak-hour congestion dynamically. Additionally, limited attention is given to automated rescheduling and analytical dashboards that support administrative decision-making. These gaps highlight the need for a unified, intelligent system capable of real-time token management, predictive scheduling, and data-driven operational insights.

2.3 Limitations of Previous Studies:

Previous analyses face several limitations. They predominantly depend on professional league data and may not generalize directly to college and club competitions where playing styles and error rates differ. Manual video annotation limits scalability, while the absence of interactive systems reduces the likelihood of routine adoption by coaches. Furthermore, none of the surveyed work combines user authentication, tournament workflow, AI models and narrative reporting into a unified, deployable platform for kabaddi.

II. METHODOLOGY

3.1 Dataset Description:

The data set used in the system consists of structured records collected through user interactions and administrative inputs. It includes user profiles, hospital details, department information, doctor duty schedules, token booking records, and consultation timestamps. The token booking dataset captures sequential token numbers, estimated consultation time, actual consultation start time, and rescheduling status. Additional datasets store hospital-wise patient inflow patterns and department-wise service demand. These datasets collectively support analytics, visualization, and machine learning model training for rush prediction and scheduling optimization.

3.2 Data Preprocessing:

Data preprocessing involves cleaning missing values, normalizing time-based data, and encoding categorical variables such as department names and hospital identifiers. The processed dataset is split into training and testing subsets to evaluate predictive performance. Machine learning models such as linear regression, decision trees, and gradient boosting algorithms are implemented to predict patient inflow and estimated waiting times. The models learn from historical token booking patterns and operational data to generate accurate forecasts. Continuous data updates allow the system to adapt to changing hospital demand trends.

3.3 System Architecture / Framework:

The proposed system architecture is designed as a modular and web-based framework that supports real-time hospital token booking and queue management. It consists of a user interface layer for patients and administrators, a backend processing layer for handling authentication, scheduling, and analytics, and a database layer for secure data storage. The backend integrates predictive models to estimate consultation time and identify peak-hour conditions, while automated scheduling dynamically manage token allocation and rescheduling. This layered architecture ensures scalability, efficient data flow, and reliable system performance, making it suitable for high-demand healthcare environments.

3.4 Algorithms / Models Used:

The proposed system employs machine learning algorithms to enhance scheduling accuracy and queue management efficiency. Regression models are used to estimate patient waiting and consultation times based on historical data, queue length, and department type. Classification and time-series models are applied to predict peak-hour rush conditions by analyzing booking patterns and time-based trends. In addition, decision tree-based optimization techniques support automated token rescheduling during delays or high-demand periods. These models collectively enable intelligent decision-making and real-time adaptability within the system.

3.5 Tools and Technologies:

The Smart Hospital Token Booking and Queue Management System is developed using modern web technologies to ensure reliability and ease of use. Python with the Flask framework is used for backend development to handle server-side logic and API integration. The frontend interface is designed using HTML and CSS to provide a responsive and user-friendly experience. SQLite is employed as the database management system for secure storage and efficient retrieval of application data. Machine learning models are implemented using standard Python libraries to support predictive analytics and scheduling optimization. These tools collectively contribute to the scalability, security, and performance of the system.

3.6 Evaluation Metrics:

The performance of the proposed system is evaluated using standard metrics to assess prediction accuracy and system efficiency. For predictive models, metrics such as accuracy, precision, recall, mean absolute error, and root mean square error are used to measure the reliability of rush prediction and consultation time estimation. System performance is assessed by analyzing average patient waiting time, consultation delay, and system response time under varying user loads. These evaluation metrics provide a comprehensive assessment of the effectiveness and robustness of the proposed system.

III. EXPERIMENTAL RESULTS AND ANALYSIS:

The experimental evaluation demonstrates that the proposed system effectively improves hospital queue management and scheduling efficiency. By combining automated token allocation with predictive analytics, the system reduces patient waiting time and handles peak-hour demand more efficiently. Performance analysis confirms stable system behavior and reliable prediction accuracy, supporting its applicability in real-world healthcare environments.

IV. DISCUSSION:

5.1 Interpretation of Results:

The experimental results indicate that the proposed Smart Hospital Token Booking and Queue Management System effectively addresses key challenges in patient flow management. The reduction in waiting time and consultation delays demonstrates the impact of automated scheduling and predictive analytics. Accurate rush-hour predictions allowed timely adjustments in token allocation, leading to smoother queue handling during peak periods. These outcomes suggest that integrating real-time data with machine learning models can

significantly improve operational efficiency and service quality in hospital environments.

5.2 Practical Implications

The proposed system offers practical benefits for real-world healthcare settings by improving appointment scheduling and queue management processes. Hospitals can use the system to reduce patient waiting times, manage peak-hour congestion, and optimize doctor schedules more efficiently. The availability of real-time queue information enhances transparency for patients, while analytical insights support administrators in making informed operational decisions. Overall, the system contributes to improved service delivery and better utilization of healthcare resources.

5.3 Strengths of the Proposed Approach

The proposed approach offers several strengths that enhance hospital queue management efficiency. It integrates real-time token booking with predictive analytics, enabling dynamic scheduling and timely handling of peak-hour demand. The system's modular and scalable architecture supports high user concurrency without performance degradation. Additionally, the inclusion of analytical dashboards improves transparency and supports data-driven decision-making, making the solution practical and adaptable for diverse healthcare environments.

5.4 Limitations of the Study

Despite its effectiveness, the proposed system has certain limitations. The predictive models rely primarily on historical data, which may reduce accuracy during unexpected events such as emergencies or sudden changes in patient inflow. The current implementation is tested in a controlled environment and may require further validation in large-scale hospital settings. Additionally, the system does not presently incorporate mobile application support or real-time notification services, which could further enhance user accessibility.

V. CONCLUSION:

This paper presents a comprehensive Smart Hospital Token Booking Web Application designed to optimize patient flow management through digital token allocation, automated scheduling, real-time updates, and analytical insights. By integrating web technologies with data analytics and machine learning models, the system enhances operational efficiency, reduces waiting times, and improves healthcare service transparency. The proposed framework demonstrates the potential of digital healthcare solutions in transforming traditional hospital management practices. Future work includes mobile application development, integration of real-time notifications, advanced AI-based demand forecasting, and large-scale deployment across healthcare institutions.

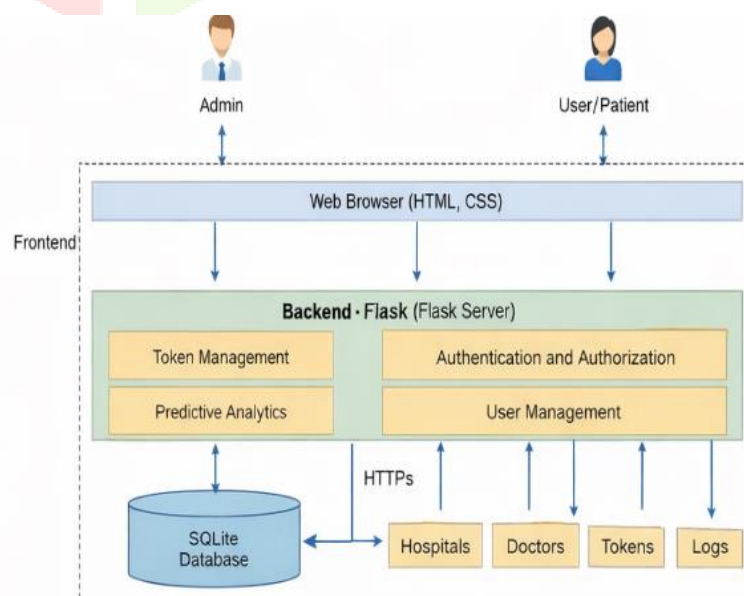


Figure 1: System Architecture of the Smart Hospital Token Booking System

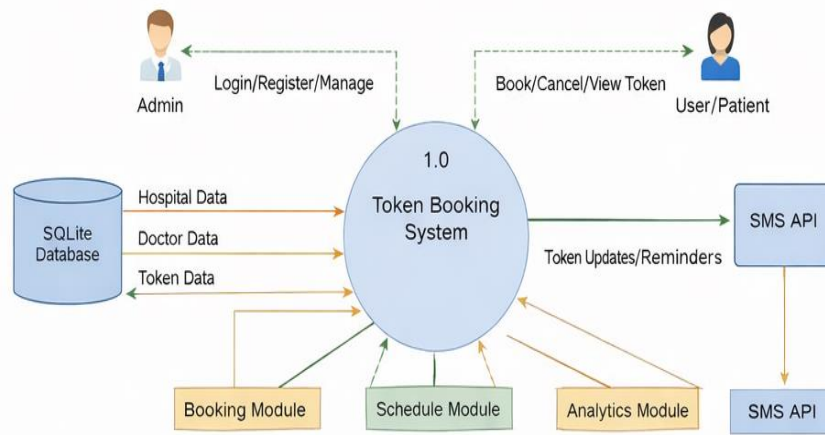


Figure 2: Data Flow Diagram (DFD) of the Smart Hospital Token Booking System.

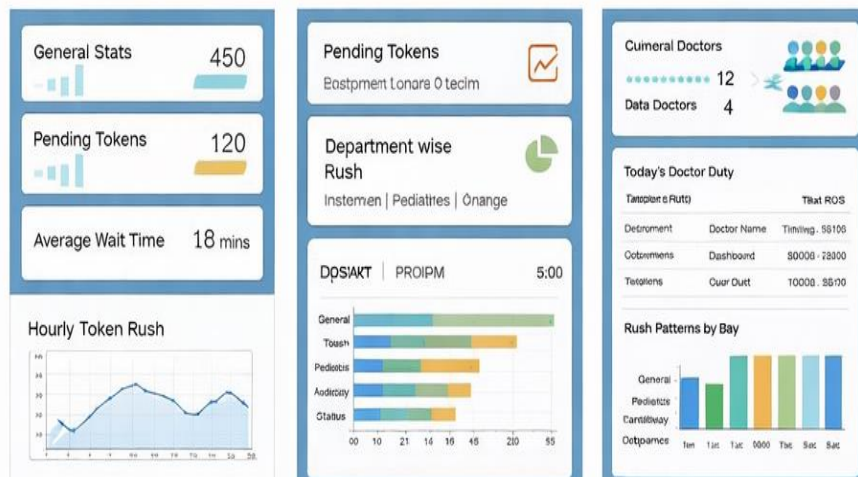


Figure 3: Analytical Dashboard showing token analysis, rush patterns, and doctor schedules.

REFERENCES

- [1] S. Patel, R. Mehta, and K. Shah, "Smart Healthcare Appointment Scheduling Using Machine Learning Algorithms," IEEE Access, pp. 45621–45634, 2023.
- [2] M. Alzahrani and A. Alotaibi, "Automated Queue Management System for Hospitals Based on Real-Time Analytics," IEEE Internet of Things Journal, pp. 11234–11245, 2023.
- [3] Kumar and P. Verma, "Digital Token-Based Patient Flow Optimization in Smart Hospitals," IEEE Transactions on Healthcare Informatics, pp. 789–801, 2024.
- [4] L. Chen, Y. Zhang, and H. Wang, "Predictive Analytics for Hospital Queue Management Using Time-Series Models," IEEE Access, pp. 22450–22463, 2024.
- [5] R. Singh, S. Nair, and A. Joseph, "Web-Based Smart Hospital Management System with Real-Time Scheduling," International Journal of Medical Informatics, pp. 102–114, 2023.